The second preferred embodiment is an apparatus for combined separation and stripping of a suspension of catalyst particles and vapour in a fluidized catalytic cracking process, wherein the apparatus includes:

(i) a vertical primary cyclone vessel, which primary cyclone is provided with a tangentially arranged inlet for receiving the suspension of catalyst particles and vapour, which primary cyclone has a tubular side wall and is open at its lower end and closed at its upper end by means of a cover provided with an opening, wherein the outlet opening is fluidly connected to a gas outlet conduit, which conduit has a gas inlet opening located at about the same level as the opening in the cover;

(ii) a stripping zone which zone is provided with means to supply stripping gas, so arranged that in use a fluidized bed is present, located such that part or all of the stripping gas leaving the stripping zone in an upward direction enters the lower end of the primary cyclone; and

(iii) one or more secondary gas-solids separators, preferably secondary cyclone separators, which are in fluid connection with the gas outlet conduit of the primary cyclone.

The apparatus according to the invention and in particular the first preferred embodiment as described here above can find use in any process in which solid particles are to be separated from a suspension of said solid particles and a gas. Examples of such process are the afore-mentioned MTBE-fluidized bed dehydrogenation process, the acrylonitrile process and fluid catalytic cracking (FCC) process. Examples of such a fluid catalytic cracking process are described in Catalytic Cracking of Heavy Petroleum Fractions, Daniel DeCroocq, Institut Français du Pétrole, 1984 (ISBN 2-7108-455-7), pages 100-114.

In a catalytic cracking process a hydrocarbon feed is contacted with a catalyst at elevated temperatures for a short period. Normally the catalyst and the hydrocarbon feed flow co-currently through a tube-like reactor. These pipe-like reactors are also referred to as riser reactors because in most cases the reactants flow in an upward motion. Although the term riser is used in this description it does not mean that the invention is limited to embodiments comprising risers through which the reactants flow in an upward direction. Contact times in the riser reactor are generally in the range of between 0.5 and 5 seconds. In the reactor riser hydrocarbons having generally a normal boiling point above 350 °C are converted to lighter products, for example gasoline being one of the major products of an FCC process. Hydrocarbons and coke will deposit on the catalyst particles. By stripping the separated catalysts with a suitable stripping medium a major portion of the deposited hydrocarbons will be separated from the catalyst. The gaseous mixture of hydrocarbons and stripping medium obtained in such a stripping zone is suitably discharged from the FCC reactor together with the FCC product. The coke is subsequently separated from the thus stripped catalyst by, optionally partial, combustion in a regenerator vessel. The regenerated catalyst, having an elevated temperature is returned to the bottom of the reactor riser.

In an FCC process solid catalyst particles can be separated from gasses in both the reactor as well as the regenerator making use of the apparatus according to the invention. On the reactor side catalyst are to be separated from the hydrocarbon product gasses. It is important that such a separation can be performed in an efficient manner making use of such coupled primary and secondary cyclones of the apparatus according to the

invention and in particular according to the two preferred embodiments as described here above. Any catalyst solids which are not separated will have to be separated further downstream, for example by making use of filters or in a so-called third stage separator. By improving the separation smaller filters can be used and/or less catalyst fines will end up in the FCC product streams. On the regenerator side catalyst particles will have to be separated from the flue gas leaving the regenerator. The amount of particles in the flue gas should be low for environmental reasons and to protect downstream equipment, like for example expansion turbines. Preferably the first preferred embodiment as described here above is used on the regenerator side.

Brief Description of the drawings

Figure 1 illustrates a partly cross-sectional presentation of a close-coupled cyclone apparatus in an FCC reactor configuration according to first preferred embodiment of the invention.

Figure 2 illustrates an FCC reactor vessel comprising the apparatus according to the first preferred embodiment of the present invention.

Figures 3-5 illustrate an apparatus according to the second preferred embodiment of the invention, wherein separation and stripping are combined in an FCC reactor.

Figure 3 illustrates an apparatus according to the invention having an external fluid catalytic cracking reactor riser and an external secondary cyclone.

Figure 4 is a variation of the apparatus of Figure 3.

Figure 5 represents an apparatus in which the downstream part of the reactor riser, the primary separation and secondary cyclones and the stripping zone are contained within one vessel.